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Renewable energy issues and electricity production in Middle East compared with Iran

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ABSTRACT

This paper analyses the renewable energy issues and electricity production in Middle East compared with Iran. Nevertheless, the use of renewable energy has started to be an interesting issue for people and also governments in Middle East, especially in Iran where all different types of renewable energy sources (RES) are available and also possible to implement for gaining required energy. There are many different kinds of renewable energy sources like geothermal, bio fuel, tidal and so on, but wind and solar energies are more available and accessible than other types in Middle Eastern countries. Nowadays, the rapidly increasing demand for electrical energy and the high restriction on pollution levels have led to an increasing interest in large-scale utilization of renewable energies across many countries in Middle East. This paper analyzes the electricity production in Middle East and also reviews different aspects of renewable energy issues in Iran.

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1. Introduction

The Middle East lies at the juncture of Eurasia and Africa and of the Mediterranean Sea and the Indian Ocean. It is the birthplace and spiritual center of the Christianity, Islam, Judaism, Yezidi, and in Iran, Mithraism, Zoroastrianism, Manichaeism, and the Bahaii Faith. Throughout its history the Middle East has been a major center of world affairs; a strategically, economically, politically, culturally, and religiously sensitive area [1]. Middle East is located in western part of the Asia which includes countries of Iran, Saudi Arabia, Bahrain, Israel, Oman, Jordan, Syria, Kuwait, UAE, Lebanon, Yemen, Qatar and Iraq. Renewable energy sources (RES) could be utilized to generate electricity for other different purposes. There are many different kinds of renewable energy sources like geothermal, bio fuel, tidal and so on, but wind and solar energies are more available and accessible than other kinds in Middle Eastern countries.

Wind power is a technology set to change the way the world lives, with many countries soon likely to find it the cheapest way of producing electricity. Global wind generating capacity now stands

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at 9600 MW—a 26% increase from December 1997 [2]. Wind energy is a part of renewable energy source and is diffuse. The wind energy technology is mature and well established. Interest in wind energy is growing worldwide because of its environmental benefits and the advancement of its technology, which is being competitive with conventional energy technologies. Wind energy can be harnessed for grid and non-grid electricity generation, water pumping, irrigation and milling [3].

Widespread use of wind turbines really began at the start of the 1990s, following a short wind energy boom at the beginning of the 1980s in California and a few installations in Denmark [4,5]. Wind turbine generated a projected 21 billion KWh of electricity in 1999, which is enough power for 3.5 million suburban homes. Despite the wind power provides less than 1% of the world's electricity at present, growth rates could make wind a major power supplier soon. Wind power is also one of the world's most rapidly expanding industries, valued at roughly US$1 billion in 1998 [2]. Nowadays, the rapidly increasing demand for electrical energy and the high restrictions on pollution levels have led to an increasing interest in large-scale utilization of wind energy. There are generally two ways by which wind power may be used economically as a significant form [6]. The first lies in the employment of large turbines within wind farms integrated into a power system, and the second possibility is by means of hybrid systems comprising wind generation with other renewable and conventional systems. The large-scale utilization of wind energy will enable many countries to depend on their own resources for the generation of electricity rather than on costly imported fuels. This goal becomes achievable day after day because of the significant improvements in the capacity and performance of the recent wind turbines. Moreover, the experience in the wind energy industry has reached quite a high level in the field of manufacturing and application. This inevitably adds more merits to the wind energy exploitation worldwide [5].

There is also another common method for gaining electricity through utilization of solar energy which is available through all Middle Eastern countries. Because of the low price of oil in Middle East, there has not yet been a serious challenge to implement and also gain energy from renewable sources like solar, wind or geothermal and any other kinds yet.

2. World market shares for manufacturing of wind turbines

World market shares for manufacturing of wind turbines in 2001 were: Denmark about 45%, Germany about 24%, Spain about 12% and the USA about 13%. The world's largest wind turbine manufacturer is the Danish company, which markets a pitch-regulated machine with a standard gearbox drive train. In 2001 the Danish wind turbine industry, including sub-suppliers, employed an estimated 20,000 people. Denmark has had continuous support for wind energy since the beginning of the 1980s and also has produced an installed wind energy capacity of approximately 2500 MW by the end of 2001. In a year with average wind conditions, wind energy covers almost 17% of Denmark's electricity demand [3].

At the end of 2003 there were more than 68,000 wind turbines installed worldwide corresponding to about 40,300 MW accumulated capacity (Table 1).

The distribution of the 40,300 MW by continent is as following in which USA with 6905 MW has the highest distribution in the world (Table 2).

As it appears more than 80% of the total global capacity was implemented in only five countries: Germany, Spain, USA, Denmark, and India. The largest manufacturing capacity is based in Denmark, Germany, and Spain. The technological development within wind energy has been extraordinary since 1980, increasing the size of the largest commercially available wind turbines from 50 kW to about 4500 kW (with prototypes up to 6 MW or larger planned) [3].

Table 1
Distribution of countries related to wind energy capacity [3]

Country	MW
USA	6,361
Germany, Denmark and Spain	24,108
India	2,125
Africa	211
Others	95

Table 2
Distribution of continents related to wind energy capacity [3]

Continent	MW
America	6905
Europe	2937
Asia	3790
Africa	211
Others	95

3. Alternative energy sources

Iran's renewable energy consumption is low. With 9% of the world's oil reserves and 15% of its natural gas reserves (80% of which have not been developed), Iran has an abundant supply of fossil fuel resources, which tends to discourage the pursuit of alternative, renewable energy sources. Iran's 1997 renewable energy consumption (including hydropower, solar, wind, tide, geothermal, solid biomass and animal products, biomass gas and liquids, and industrial and municipal wastes) totaled 106 trillion Btu, a 6% increase over the previous year. In an attempt to diversify its energy mix from a primarily oil-based economy, Iran is increasing its hydroelectric capacity. Several hydropower plants are currently in operation, and several more are under construction. In addition, Iran would like to increase its nuclear power usage in order eventually to meet 20% of the country's electricity demand, but international concerns about Iran's use of nuclear power for purposes other than electricity generation have limited the country's nuclear capacity [7]. Recently, Iran has paid a great attention towards harnessing wind energy from suitable sites with acceptable wind potential in different parts and locations. Unfortunately, there has not been a wind map for survey and installing the wind turbines yet. But in 2006 Renewable Energy Organization of Iran (SUNA) started to complete the job in order to provide the national wind map or wind atlas. Solar energy is also another form of renewable kind which is available in most of the regions especially in central and southern parts of Iran. In order to provide a broad wind resource assessment over Iran, the wind characteristics must be studied in detail. Wind resource assessments can be divided into two main areas: regional assessment and micro-sitting. Regional assessment is overall estimation of the mean energy content of the wind over a large area. Micro-sitting is to position one or more wind turbines on a land in order to maximize the overall yearly energy output of a wind farm. During the last 2 years, many 40-m towers have been installed in many provinces in order to provide wind information for Iranian wind atlas. A precise prediction of the wind speed at a given site is essential for the determination of regional wind energy resources. Because of aerodynamic reasons, the power output of a wind turbine is proportional to the third power of the wind speed. It is a

Table 3
Energy consumption for Iran from 1980 to 2000 [7]

Year	Quadrillion Btu
1980	1.6
1982	1.6
1984	2.2
1986	2.4
1988	2.5
1990	3.0
1992	3.2
1994	3.5
1996	4.0
1998	4.5
2000	4.6

fact that, especially in complex terrain, wind energy content may vary significantly from one region to another. Therefore, wind data taken over many years are utilized to calculate wind climatology. European Wind Atlas [8] is a good example of this. Some other wind resource maps such as Wind Atlas of Russia [9] and the Irish Wind Atlas [10] also have been prepared. The whole area of renewable energy options needs further survey and examination. For example, wind energy is gaining more attention internationally, and countries such as India, South Africa, China, and many others have invested in large wind generators. Primary studies indicate that Iran has regions where wind and solar energies may be a viable alternative which must be considered.

4. Energy consumption

A major factor behind the suffocating air pollution in major cities is the dramatic rise in energy consumption. Iran's total energy consumption jumped from 1.6 quadrillion Btu in 1980 to 4.7 quads in 2000 which is a very high consumption rate. It should be noted that most of the consumption was accounted for by gasoline.

Overall, natural gas makes up about 50% of the energy consumed in Iran, with oil (48%) making up much of the rest and coal accounting for only 1%. Per capita energy consumption in 2000 was 73.8 million Btu, which is only one-fifth of the U.S. level of 351.1 million Btu, but is still on the increase. Iran's energy intensity (energy consumption per GDP dollar) at 39,265 Btu/ $1995 remains above the level of most western countries, but below many countries in the former Soviet Union and the Middle East [7]. In 2000, US energy intensity was 10,919 Btu/$1995 which is almost one-fourth of Iran (Table 3).

5. Carbon emissions

Iran's energy-related carbon emissions have been on a steady climb for two decades. Since 1980, carbon emissions in Iran have risen by 240%, from 33.1 million metric tons emitted in 1980 to 80.8 million metric tons emitted in 2000. There has been an increasing number of cars, and automobile exhaust has contributed greatly to the fact that Iran now accounts for 1.3% of the world's total carbon emissions [7]. Based upon Table 4, the figures show the rapid growth in carbon emission from 1980 to 2000 which is not acceptable if we consider environmental regulations. Governments have been trying to resolve this problem, but so far there has been less success.

Table 4
Carbon emission for Iran from 1980 to 2000

Year	Million Metric Tons
1980	33
1982	36
1984	43
1986	46
1988	48
1990	53
1992	62
1994	66
1996	70
1998	78
2000	80

6. Government policy perspectives

The objective of future energy strategies should be to address, on a priority basis, the main energy-environment problems faced today [11]:

- The lack of access to clean, convenient, affordable, and environmental friendly energy services in general.
- Establishment of solar farms in many parts of Iran.
- Development of wind farms in windy areas.
- Use of geothermal energy in appropriate locations.
- Inefficient commercial energy use throughout the formal economy, which is encouraged by low energy prices.
- Over reliance on the environmentally harmful use of fossil fuel in power generation, industry, and households.
- Eliminate the subsidiary for vehicles and limitation of fuel consumption.
- Increase the price of fossil fuel in order to lower the consumption rate.
- Export gas from Persian Gulf to India through Pakistan.
- Subsidize on solar products like water heater.

7. Public's attitude towards wind power in Iran

In general, Iranians are interested to have renewable sources of energy like wind, solar, geothermal and other different kinds of environmentally friendly energies. For example people in city of Yazd which is located in central part of Iran and in middle of desert, have been using solar water heaters for many years. As a matter of fact, the access to fossil fuel is easy and inexpensive. But Iranian people as well as others would like to have clean energy for different purposes. There are many legal issues and problems towards wind turbine sites in many countries. But there have not been these kinds of problems in Iran yet. People are friendly with renewable energy establishment and legal issues are not important factors for them yet.

7.1. Environmental Impact

During normal operation of wind turbines, there are no emissions to the air, water, or soil, because there is no burning of fossil fuels. Every GWh of power generated from wind prevents the emission of certain amount of pollution associated with burning fossil fuels to produce such. The environmental impact of operating wind turbines include: it may damage birds as a result of collisions with towers and blades and this can be considerable when located on the migration routes and flyways of birds. The noise produced by wind turbines is also a nuisance to nearby inhabitants. Visual impact or the effect of shadow of the rotor blades, when installed close to work area or residences, can be unpleasant. Visual intrusion is also a function of the location of the wind farms. Industrial emissions from energy required to produce the materials used to construct a wind turbine (steel, concrete, other materials) [3].

Table 5
Electricity production in Middle East [12]

	Iran	Saudi Arabia	Bahrain	Syria	Oman	Israel	Iraq	Lebanon	Kuwait	Yemen	UAE	Jordan	Qatar
Production of electricity (GWh) from													
Coal	0	0	0	0	0	37,007	0	0	0	0	0	0	0
Oil	28,461	81,279	0	14,622	2,070	7,738	31,802	9,072	32,787	4337	1,329	4,410	0
Gas	125,393	78,596	8448	13,208	9,429	4,341	0	0	8,469	0	51,088	4,495	13,233
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydro	10,627	0	0	4,247	0	28	493	1,120	0	0	0	53	0
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0	0	0	0	0	0	0
Other sources	0	0	0	0	0	11	0	0	0	0	0	3	0
Total production	164,481	159,875	8448	32,077	11,499	49,125	32,295	10,192	41,256	4337	52,417	8,961	13,233
Imports	2,170	0	0	0	0	0	1,318	216	0	0	0	788	0
Exports	−1,837	0	0	0	0	−1,459	0	0	0	0	0	0	0
Domestic supply	164,814	159,875	8448	32,077	11,499	47,666	33,613	10,408	41,256	4337	52,417	9,749	13,233
Statistical differences	0	0	0	0	0	139	0	0	0	0	0	15	
Total transformation	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity plants													
Heat plants	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy sector	8,974	19,234	251	3,665	540	4,609	0	0	11,063	419	1,867	675	0
Distribution losses	27,762	11,843	676	7,596	1,779	1,383	2,019	1,561	4,474	977	3,466	1,179	916
Total final consumption	128,078	128,798	7521	20,816	9,180	41,813	31,594	8,847	25,719	2941	47,084	7,910	12,317
Industry	43,697	16,399	1492	8,781	944	11,615	0	2,322	0	0	6,449	2,300	2,672
Transport	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential	40,564	73,365	3935	12,035	4,962	13,823	0	3,373	17,103	2093	17,461	2,745	2,339
Commercial and public services	23,125	36,125	2057	0	3,098	12,477	0	1,482	8,616	264	18,476	1,604	1,820
Agriculture/Forestry	15,504	2,909	37	0	0	1,750	0	0	0	0	4,698	1,261	0
Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	5,188	0	0	0	176	2,148	31,594	1,670	0	584	0	0	5,486

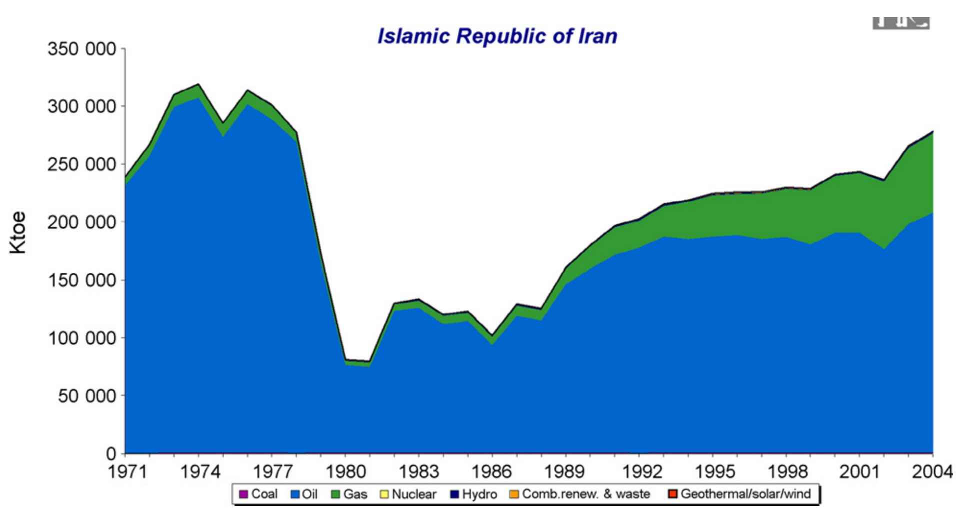


Fig. 1. Different sources of energy in Iran [13].

8. An overview of electricity production in Middle East

Based upon the information from Table 5, it is clear that up to year 2004, there has not been enough effort toward using renewable energy in Middle East. Most of these countries have been using oil and gas in order to produce electricity. There are few countries like Iran, Israel, Syria, Iraq, Lebanon, and Jordan which have been able to use dams for acquiring electricity. The only country which had been using coal and other sources of energy is Israel. It is clear from data that as long as there is a cheap source of energy like oil and gas, there is not much interest to implement renewable sources of energy in Middle East. But fortunately, recently many of these countries have paid attention in order to use renewable energies for different purposes. In Iran there is a plan to provide Wind Atlas in near future. There are also some wind farm sites which have been producing electricity in north and northeastern parts of Iran like Manjil and Binalood areas with high capacity to generate electricity.

It is also clear from data in Fig. 1 that main source of energy in Iran from 1971 was oil in which after a sharp decrease in 1978 it reached to its lowest in 1980. Natural gas consumption also increased rapidly and government has invested billions of dollars

in order to build new gas pipelines to most of the cities and remote villages in order to minimize dependency on oil which is also another kind of the fossil fuel too.

9. Conclusions

This study has explicitly demonstrated the presence of different sources of renewable energies in Middle East as well as in Iran. Development of a more sustainable energy sector in the Middle East seems promising for the near future. Most of the key factors related to this technology are addressed by the renewable energy (RE) programs initiated in the Middle East. The development of renewable energy and energy efficiency methods requires a coherent supportive strategies framework. In theory and practice, Middle Eastern countries have not developed a clear, independent, integrated, and entire strategy framework for energy sustainability. More actions should be undertaken that address the development of a domestic market for implementing renewable energy. Development of a self-sustaining RE market is a necessity for the further development, application, and diffusion in Middle East on the long term. A major factor behind the suffocating air pollution in major cities is the dramatic rise in energy consumption. It can be concluded that the simultaneous, massive introduction of different types of RES can significantly contribute to the necessary reduction of CO_2-equivalent emissions.

Iran, with its young population and growing energy demand, its fast growing urbanization, and its economic development, has been one of the countries in the world with high rate of energy consumption. On the whole, Iran has substantial reserves of renewable energy sources. There is also significant potential for wind and solar power development too. Iran's geothermal potential is significant in some known locations like in Northwest parts, but only a small portion is considered to be economically feasible.

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